

Special Issue: Design Theory and Methodology

To create a journal that addressed a breadth of topics like vibration, wear, impact, and fatigue in mechanical components, it may have seemed logical that this journal was born in the late 1970's under a rather generic moniker of "mechanical design." But over its 39 years of existence, the journal grew quickly to cover broader notions of mechanical design— notions covering the mechanical design *process* as well as mechanical design *products*. In the late 1980's, the focus on the design process alone had accumulated enough interest to lead several researchers to dedicate an entire conference to the theories and methodologies of design. The first ASME DTM (Design Theory and Methodology) Conference took place in Montreal, QC, Canada, in the summer of 1989. It included 13 papers divided into three themes that have since blossomed, merged, divided, and persevered: (1) Design Process Evaluation, (2) Knowledge Representation and Design Process, and (3) Employing Computation in Design. This year, the ASME DTM Conference will celebrate its 27th year with a dozen themes and 48 papers. Participants to the annual international conference will attest that it is always a well-attended (usually standing room only) and enthusiastic conversation about the mechanical engineering design process. Clearly, engineering design is essential to the success of any industry endeavor—whether it be the success of a particular engineering firm, the success of a public infrastructure project, or the success of a high-tech invention. And, this DTM community has sought to explicitly define the extent and underlying common phenomena of the engineering design process. It is clear that in addition to understanding our products and the underlying physics that govern their success, we, as engineers, must understand our design process and the theories and methods that define it and push it forward.

In celebration of the Design Theory and Methodology Conference, the recent conference and committee chairs have worked together to create this special issue of JMD with a focus on themes commonly depicted in the conference. In fact, several of these special issue papers appeared in an earlier form at the conference, while others were incorporated to round out the theme and all of its subgenres. We would also like to thank Associate Editor Carolyn Seepersad for coordinating the reviews for one of the papers in this special issue.

As a part of this special issue, we would also like to acknowledge the tremendous contributions Professor Clive Dym made to our community and engineering design education. His career spanned over 40 years. Professor Dym was a renowned engineering educator and researcher inspiring many students and faculty. He transformed engineering design education and led the creation of the book *Engineering Design: A Project-Based Introduction*, which is used by many universities to teach engineering design. He was Professor Emeritus of Engineering Design and Director of the Center for Design Education at Harvey Mudd College, Claremont, CA. He held many honors including the Fletcher Jones Design Chair, and the National Academy of Engineering Gordon Prize for his contributions to engineering design education. He continued to have impact throughout his life with his most recent contribution igniting the North American Chapter of the Design Society to help better connect the design theory and methods community in ASME to the broader international community. He

received the inaugural Design Theory and Methodology award and was invited as a guest editor for this special issue.

Several of the papers in this issue present new design methods. The paper by Hahn, Marconnet, and Reid presents a seven-step framework for determining customer needs from DIY practitioners. The approach is illustrated for lead users in the hair-care industry. Königseder and Shea provided a new method for supporting computational design synthesis development and application and included two case studies. In "Design for Sustainable Use of Appliances: A Framework Based on User Behavior Observations," energy overuse is presented as a failure mode brought about by user behavior. By understanding why and how users overuse energy in devices, an engineering designer can perhaps change a design to prevent this overuse. "Design Roadmapping: A Framework and Case Study on Planning Development of High-Tech Products in Silicon Valley" describes a framework that parallels existing product and technology roadmapping processes to overcome differences due to customer needs not being considered with technology choices.

Other papers focus on understanding the phenomena related to design—whether it be on the part of the designer or the end-user. The paper, "The Effects of Gender and Idea Goodness on Ownership Bias in Engineering Design Education," evaluates biases that affect decisions during the design process. In this paper, the authors show how male designers have a larger ownership bias toward their own ideas and women are more likely to prefer the designs by their team members. The paper, "Effect of Product Representation in Visual Conjoint Analysis," is an interesting study showing how representation will affect the consumer preference of design options. The authors find user preference toward particular features varied depending if a sketch, solid model, or a prototype of the product was shown to the users. The paper, "Discovery of Mental Metadata Used for Analogy Formation in Function-Based Design," furthers our understanding of design by analogy. In particular, it finds from protocol studies with engineering students that in addition to previously researched functional analogies, flow analogies are common and useful during design. This new finding is helpful in developing computational design support systems for designers.

Finally, a set of papers look at the existing design methods in hopes of understanding their interactions and effectiveness. Daly, Seifert, Yilmaz, and Gonzalez compare three techniques for engineering idea generation: Design Heuristics, Morphological Analysis, and Individual Brainstorming—illustrating the strengths of each technique and exposing the value of using multiple approaches for idea generation. Gericke, Kramer, and Roschuni examine how designers discover and adopt design methods. Through a thorough interview process, the authors draw conclusions on how one might best present design methods online to help design practitioners find methods useful to them. Finally, "Design Principles: Literature Review, Analysis, and Future Directions" is a literature review collaboration authored by three reputable professors that reflects on four decades of research on the engineering design process. Through the retrospective, the authors formally define and categorize important aspects of this growing corpus of design theory and methodology research.



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